

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
7 August 2003 (07.08.2003)

PCT

(10) International Publication Number
WO 03/064874 A1

(51) International Patent Classification⁷: **F16C 33/30, 33/62**

(21) International Application Number: PCT/NL03/00066

(22) International Filing Date: 30 January 2003 (30.01.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1019860 30 January 2002 (30.01.2002) NL

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(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.



WO 03/064874 A1

(54) Title: **ROLLING BEARING HAVING CERAMIC ROLLING ELEMENT AND STEEL INNER OR OUTER RING**

(57) Abstract: Roller bearing comprising an inner and outer ring, a number of rolling elements and a cage. The inner and outer ring comprise steel material and the rolling element a ceramic material. Either the inner or the outer ring is coated with a solid lubricant coating. The solid lubricant coating comprises a metal doped molybdenum disulfide.

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Rolling bearing having ceramic rolling element and steel inner or outer ring.

The invention relates to a roller bearing comprising at least an inner or outer ring, a number of rolling elements and a cage, said inner or outer ring comprising ball
5 bearing steel material and said rolling element comprising a ceramic material, wherein said inner or outer ring is coated with a solid lubricant coating

In many rolling bearing applications fluid lubricants such as grease and oil are not allowed to use. An example is a reactor of a polyethene processing plant, inside a CO₂ dyeing vessel for textile processing, vacuum and clean room environments for
10 semi-conductor processing, instruments operated at ultra-high vacuum and aero-space. In these cases grease and/or oil particles could be highly contaminating and are not acceptable. However, if such rolling bearings run in a dry environment without fluid lubricant premature failure or even seizure might be expected due to adhesive wear, cold welding and heat generation from the high friction resulting.

15 To solve this problem the use of solid lubricant coatings has been proposed. Examples are PTFE coatings, molybdenum disulfide MoS₂ coatings, graphite coatings and diamond like carbon (DLC) coatings.

In the abstract of the Japanese patent application 03255224 the use of molybdenum disulfide on the raceway rings is disclosed.

20 DLC and (metal doped) MoS₂ have a strong adhesion to a steel substrate, with higher hardness, significant lower friction coefficient and therefore much higher wear resistance than those of conventional solid lubricants. Furthermore particle generation of such solid lubricant coatings is relatively low and there is no outgassing from the solid lubricants making them especially suitable for instruments operated at ultra-high
25 vacuum and in clean room environments.

It is known in the art to coat roller elements with these solid lubricant coatings to improve service life of rolling bearings running under dry conditions.

However, it revealed that under severe circumstances such as in applications for pumps, sliding contacts and gears still premature damage can be observed.

30 Molybdenum disulfide as such is relatively soft material and has a low wearing resistance. It cannot withstand height loadings. In the atmospheric conditions erosion is a serious problem.

The invention aims to provide a rolling bearing to be used without a fluid lubricant which has improved loading properties.

According to the invention this aim is realised in that said solid lubricant coating comprises metal doped MoS_2 .

5 According to the invention a rolling bearing is proposed having an inner and/or outer ring of ball bearing steel being provided with as metal doped MoS_2 . To the use of metal doped MoS_2 a more particular titanium doped molybdenum disulfide the hardness of the lubricant considerably increases to getting with this wear resistance. The hardness of molybdenum disulfide as such has been found to be around 200 HV. If
10 a metal is added hardnesses of 1000-2000 HV can be realised. Because of the presence of the metal in the molybdenum disulfide protection against oxidation is obtained.

The metal used such as titanium is preferably present in the quantity of 2-20% by weight and more particular about 10% by weight. The rolling element comprises a ceramic element. An example is a Si_3N_4 ceramic material.

15 The cage for the rolling element can comprise both a plastic and a metallic material. This is dependent from the surroundings in which the rolling bearing is used. Under extreme conditions a metallic cage being realised through powder metallic techniques would also be a feasible option.

Although the invention might be realised with a rolling element comprising a
20 ball, according to a preferred embodiment the rolling element comprises a roller

If a metal doped MoS_2 coating is used it will be understood that such coating is realised in a number of layers.

If a MoS_2 layer has to be provided on a steel substrate titanium is used as intermediate layer. So in this case a number of layers (10-100) can be provided.

25 According to a preferred embodiment of the invention the total coating thickness so obtained is between 0,1 and 4 micron and more particular between 1 and 2 micron. Depositing (PVD) is realised on the finished bearing component i.e. no further grinding or rehardening is effected after deposition of the coating.

The metallic inner or outer ring can comprise stainless steel material, i.e. steel
30 having increased chromium and nickel content.

The ceramic material rolling element can also be coated with a solid lubricant coating.

Claims

1. Roller bearing comprising at least an inner or outer ring, a number of rolling elements and a cage, said inner or outer ring comprising ball bearing steel material and said rolling element comprising a ceramic material, wherein said inner or outer ring is
5 coated with a solid lubricant coating, characterised in that said solid lubricant coating comprises metal doped MoS_2 .
2. Roller bearing according to claim 1, wherein said metal comprises titanium.
- 10 3. Roller bearing according to claim 1 or 2, wherein 2-20% by weight metal is provided in said lubricant coating.
4. Rolling bearing according to one of the preceding claims, wherein said rolling element comprises a Si_3N_4 material.
15
5. Rolling bearing according to one of the preceding claims, wherein said rolling element comprises a roller.
6. Rolling bearing according to one of the preceding claims, wherein said inner or
20 outer ring comprises a stainless steel.
7. Rolling bearing according to one of the preceding claims, wherein said rolling element is coated with a solid lubricant coating.
- 25 8. Rolling bearing according to one of the preceding claims comprising lubricant grease.

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16C33/30 F16C33/62

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F16C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01 33091 A (TIMKEN CO) 10 May 2001 (2001-05-10) the whole document	1,2,4,6, 7
A	PATENT ABSTRACTS OF JAPAN vol. 0160, no. 57 (M-1210), 13 February 1992 (1992-02-13) & JP 3 255224 A (MITSUBISHI ELECTRIC CORP), 14 November 1991 (1991-11-14) cited in the application abstract ----- -/--	1,3,6,7

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☒ Patent family members are listed in annex.

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Date of the actual completion of the International search

16 May 2003

Date of mailing of the International search report

23/05/2003

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 0123, no. 86 (M-754), 14 October 1988 (1988-10-14) & JP 63 140120 A (MITSUBISHI HEAVY IND LTD; others: 01), 11 June 1988 (1988-06-11) abstract -----	1,4,6,8
A	EP 0 446 723 A (KOYO SEIKO CO) 18 September 1991 (1991-09-18) the whole document -----	1,4,6,8
A	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 03, 28 April 1995 (1995-04-28) & JP 6 341445 A (SHOJIRO MIYAKE; others: 01), 13 December 1994 (1994-12-13) abstract -----	1,6,7

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 0133091	A	10-05-2001	AU 1440401 A WO 0133091 A1	14-05-2001 10-05-2001
JP 3255224	A	14-11-1991	NONE	
JP 63140120	A	11-06-1988	JP 2072939 C JP 7088855 B	25-07-1996 27-09-1995
EP 0446723	A	18-09-1991	JP 2913061 B2 JP 3255215 A DE 69109901 D1 DE 69109901 T2 EP 0446723 A1 US 5139396 A	28-06-1999 14-11-1991 29-06-1995 22-02-1996 18-09-1991 18-08-1992
JP 6341445	A	13-12-1994	JP 2991834 B2	20-12-1999

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